Space Weather Technical Forecast

Issued on Sunday, 24 March 2024 at 13:19 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further Minor/Moderate radio blackouts (R1/R2) expected. Current S2 conditions only slowly reducing. Minor to Moderate geomagnetic storms (G1-G2) expected into days 1 and 2 (24-25 Mar) given likely CME arrival and ongoing HSS, with a chance of Strong geomagnetic storm (G3) intervals.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES16 and 18 remained Moderate to High, with AR3615 producing seven separate M-class flares through the period with the highest being an M5.1 at 23/1352UTC. There are now eight sunspots on the visible disc. AR3615 remains by far the largest and most complex group on the disc, showing significant magnetic complexity although perhaps some simplification and consolidation observed in recent hours. Changes in other groups were minor by comparison. Two new sunspot regions have appeared on the disc, a small alpha spot to the south of AR3615 and an as yet unnumbered region which has rotated on the north eastern limb, this regions classification subject to change as it rotates further on to the visible disc.

No significant Coronal Mass Ejections (CMEs) observed on available coronagraph imagery over the last 24hr.

Solar Wind / Geomagnetic Activity: The solar wind at L1 measured by ACE and DSCOVR were initially at background levels but steadily rose after 23/1200UTC as earth came into contact with the HSS in association with CH12 and are currently just about at elevated levels at 500km/s. The solar wind density has largely been above average, but became well above average at 23/1316UTC perhaps as a result of an approaching CIR region. The IMF saw a similar change from initial weak positive values giving way to weak to moderate broadly negative values which slowly rotate weakly positive again towards midday before becoming moderate to strong largely negative values, peaking at -14nT at 23/2012UTC. The phi angle showed was largely negative (towards the Sun).

The net result of the above solar wind measures was Unsettled to Active activity with a Moderate geomagnetic storm (Kp6) at 24/0000UTC.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux rose following the X1.1 flare to rise above S1 levels from 23/0815UTC and above S2 levels at 23/1400UTC and remains elevated although has been on a gradual decline since 23/1800UTC. High energy electron flux (greater than 2MeV) observed at GOES16 was at Normal Background levels. The observed 24-hour fluence was below the Active threshold, with a value at 24/0001UTC of 1.24e6 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity is expected, with further M-class flares expected from primarily the highly active AR3615 through the forecast period, with a chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: There is one Earth-directed CMEs in the current forecast, this is associated with the X1.1 flare from a broad region north of AR3614 at 23/0133UTC. This produces a complex halo CME modelled to arrive later on day 1 (24 Mar) or early day 2 (25 Mar), with winds perhaps increasing to 600-700km/s before slowly declining. The other notable enhancement is from the continuing connection to the HSS associated with CH12/-, current elevated solar winds (500-550km/s) expected to ease through day 3 (26 Mar), perhaps returning to background levels by day 4 (27 Mar) in the absence of CME influence.

Initially Unsettled to Active geomagnetic activity is expected to give way to G1-G2 minor to moderate storm intervals later day 1 (24 Mar) given the expected arrival of the above CME, with a chance of G3 strong geomagnetic storm intervals. These conditions expected to continue into day 2 (25 Mar) as the influence of the CME likely continues, before being expected to generally ease into day 3 (26 Mar), becoming Unsettled to Active with a slight chance of residual G1-G2 intervals. Into day 4 (27 Mar) a return to generally Quiet to Unsettled conditions expected given likely waning HHS influence in the absence of further CME enhancement.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux at GOES18 is currently above S2 thresholds following recent X-class flare activity, and is expected to remain so through days 1 and 2 (24-25 Mar) with the ongoing HSS and likely approaching CME acting to maintain the enhancement. There is a slight chance that CME influence may see Proton flux breach the S3 threshold. Proton flux levels are thought likely to fall to S1 levels later day 2 into day 3 (25-26 Mar), before perhaps slowly falling back to background levels during day 4 (27 Mar) although confidence is low with AR3615 presenting an increasing risk of further enhancement.

High energy electron flux (greater than 2MeV) is expected to persist at background levels at first, but may respond upwards towards the end of the period given expected geomagnetic enhancement associated with the ongoing HSS and likely incoming CME. The associated 24-hour fluence is expected to persist below the Active threshold initially, but with an increasing chance of reaching Active fluence by the end of the period.

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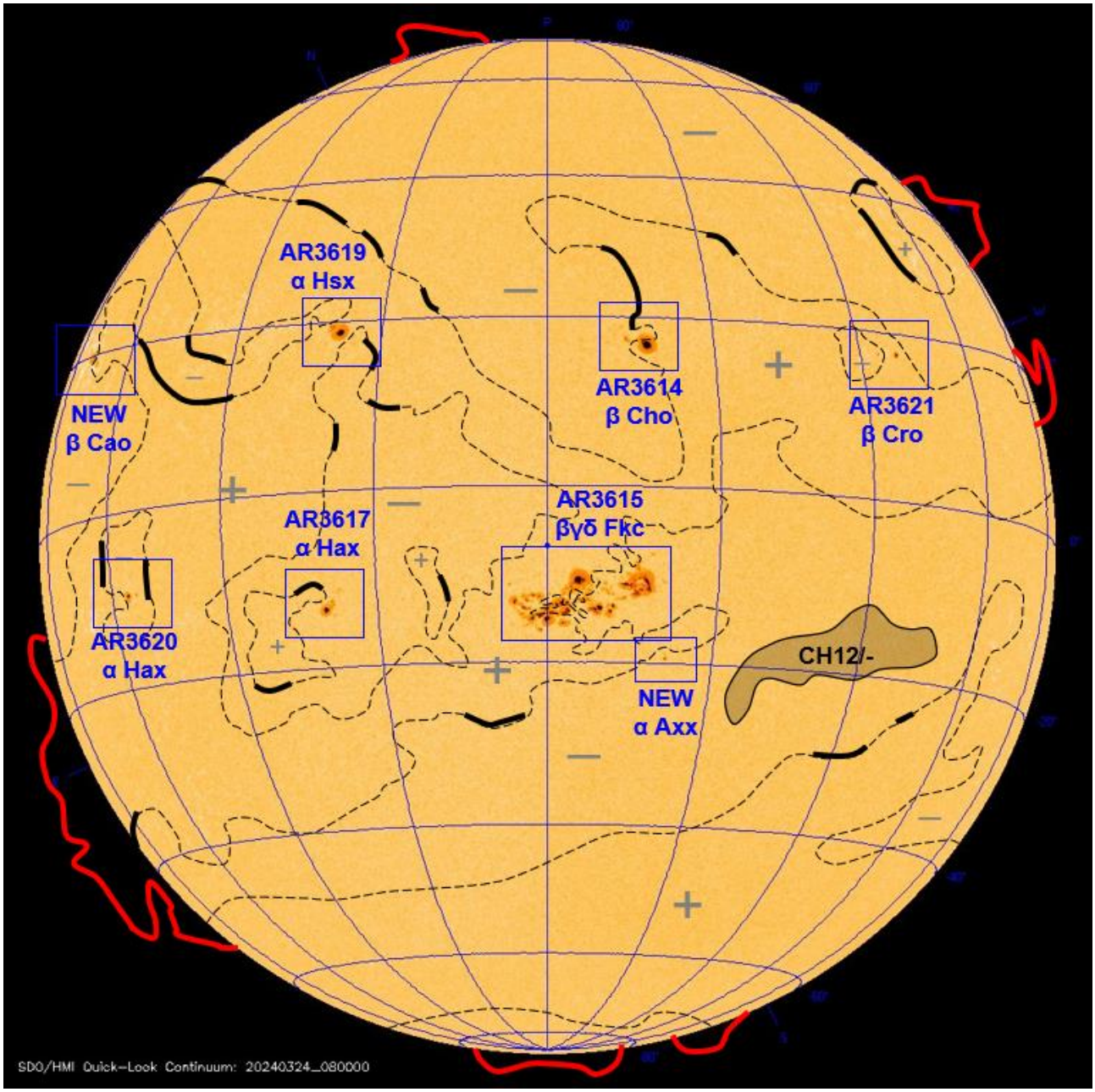
Figure 1. Solar Analysis Valid 24/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one Earth-directed CMEs in the current forecast, this is associated with the X1.1 flare from a broad region north of AR3614 at 23/0133UTC. This produces a complex halo CME modelled to arrive later on day 1 (24 Mar) or early day 2 (25 Mar), with winds perhaps increasing to 600-700km/s before slowly declining.

Current solar wind dominated by the HSS associated with CH12/- in the southeast disk, this arrived slightly earlier than expected given the persistent nature of CH12/-, bringing current elevated solar wind speeds of around 520km/s which are thought near the peak speeds expected from this feature. In the absence of CME influence current solar winds expected to generally continue through day 1 into day 2 (24-25 Mar) before beginning to ease through day 3 (26 Mar) and returning to background levels by day 4 (27 Mar).

Initially Unsettled to Active geomagnetic activity is expected to give way to G1-G2 minor to moderate storm intervals later day 1 (24 Mar) given the expected arrival of the above CME, with a chance of G3 strong geomagnetic storm intervals. These conditions expected to continue into day 2 (25 Mar) as the influence of the CME likely continues, before being expected to generally ease into day 3 (26 Mar), becoming Unsettled to Active with a slight chance of residual G1-G2 intervals. Into day 4 (27 Mar) a return to generally Quiet to Unsettled conditions expected given likely waning HHS influence in the absence of further CME enhancement.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	80	80	20	5
Strong	G3	No	30	30	1	1
Severe	G4	No	5	5	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/0423	Full	AR3514	N	1292km/s	25/0000UTC +-06hr	Nil

Figure 2: Latest MOSWOC ENLIL Ensemble output. Dominated by the expected arrival of the above mentioned CME. Note this forecast to arrive, perhaps slightly earlier than ENLIL suggests as coronal hole CH12/- poorly represented, with solar winds currently around 500-520km/s, above ENLIL expectations.

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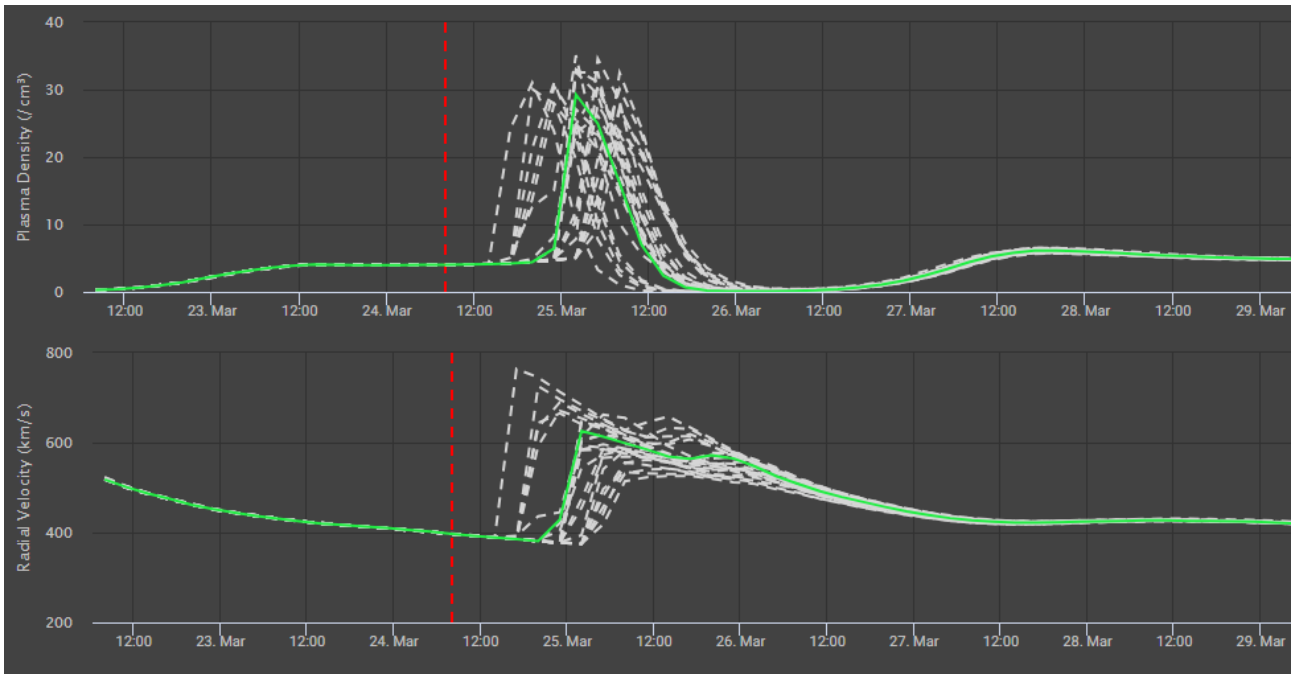

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Radio Blackouts - X-Ray Flares:
The current Earth-facing disc is almost completely dominated in terms of flare activity by AR3615, with seven distinct M-class flares through the period. This region continues to comprise a large number of spots although ongoing areal growth seems to be resulting in some consolidation. Significant mixing of its constituent magnetic polarities remains evident, particularly across the trailing portion, and the regions continues to display a Mt Wilson Beta-Gamma-Delta configuration, although once again perhaps signs of some simplification in recent hours. This region will continue to be closely monitored. The X1.1 flare on the 23rd was primarily associated with AR3614, which remains generally stable and much more magnetically simple, though it lies within a large plage region.

AR3615 (and AR3614) are expected to remain on the visible disk throughout the four days of the forecast period. No significant new sunspot regions are currently signaled to return onto the disk, however the as yet unnumbered region in the northeast does appear to be active with a full assessment of the regions yet to be made as it slowly rotates further into view. All considered, further M-class flare activity is expected through the period with the frequent flaring from AR3615 resulting in a high probability of activity. There is also a chance of isolated X-class activity primarily from this region, although for now regular energy discharge perhaps seems to be mitigating that risk somewhat.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	90	90	90	90
Very Active	R3 to R5 X Class	No	30	30	30	30

Figure 3: Latest 24hr GOES 16/18 X-ray flare trace and magnetogram image of AR3615.

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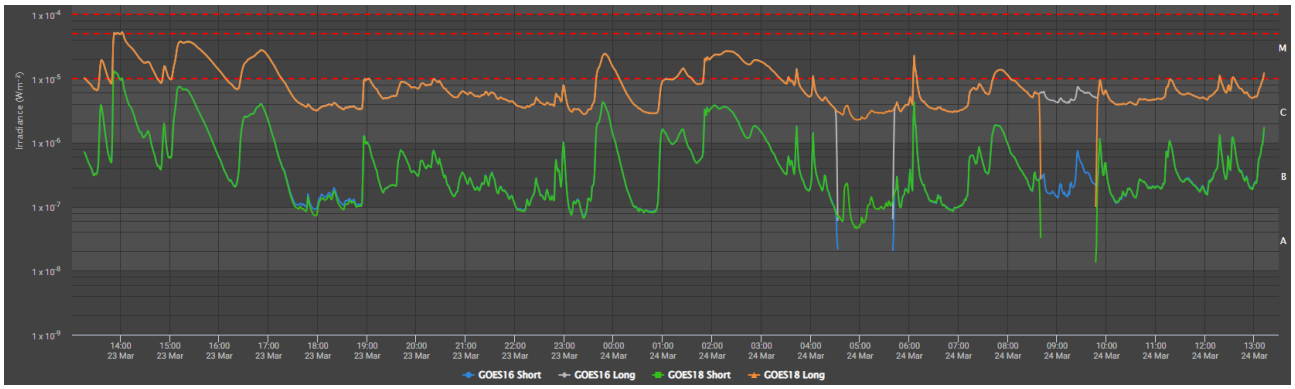

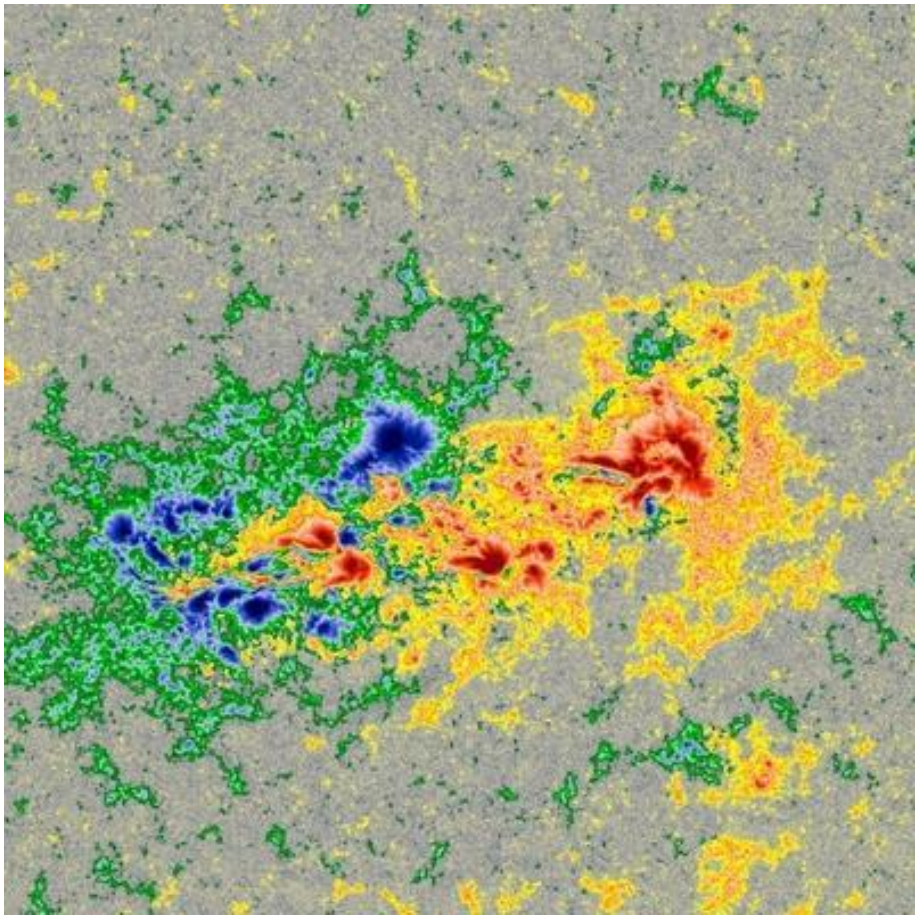

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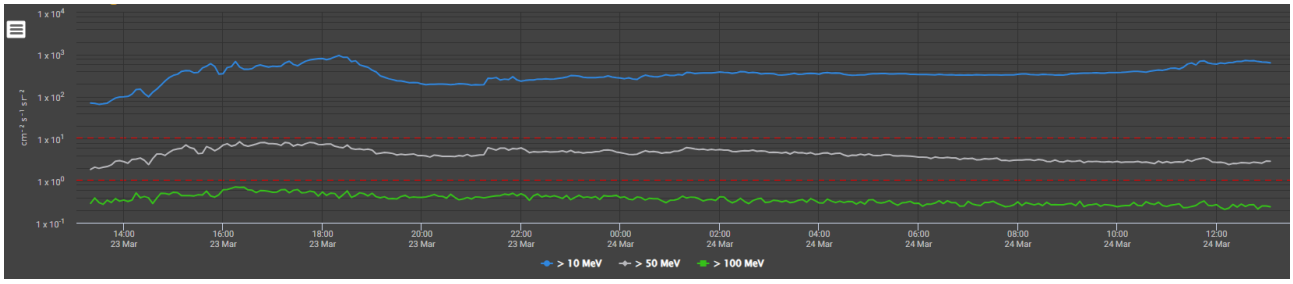
Solar Radiation Storms - (High Energy Protons):
High energy proton flux, as observed by GOES18 is currently at S2 levels following an increase associated with the X1.1 flare at 23/0133UTC, reaching a current peak of 956pfu at 23/1820UTC. Since then it has been on a generally level trend with the likelihood that the current HSS is helping to maintain the enhancement. A further increase is possible given the expected CME arrival later on day 1 into day 2 (24-25 Mar), with a slight chance of reaching S3 levels. A slow decline is then expected from later day 2 (25 Mar) in the absence of further significant flare activity, perhaps falling back to background levels by later day 3 into day 4 (26-27 Mar), although confidence is reasonably low given the number of different factors as well as the dominant AR3615 making continued progress westward through this four-day period to gradually increase the risk of further enhancement in association with significant flaring.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	90	70	30
Very Active	**≥ S3 ***	No	10	10	5	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: Latest 24hr GOES18 Proton Flux trace



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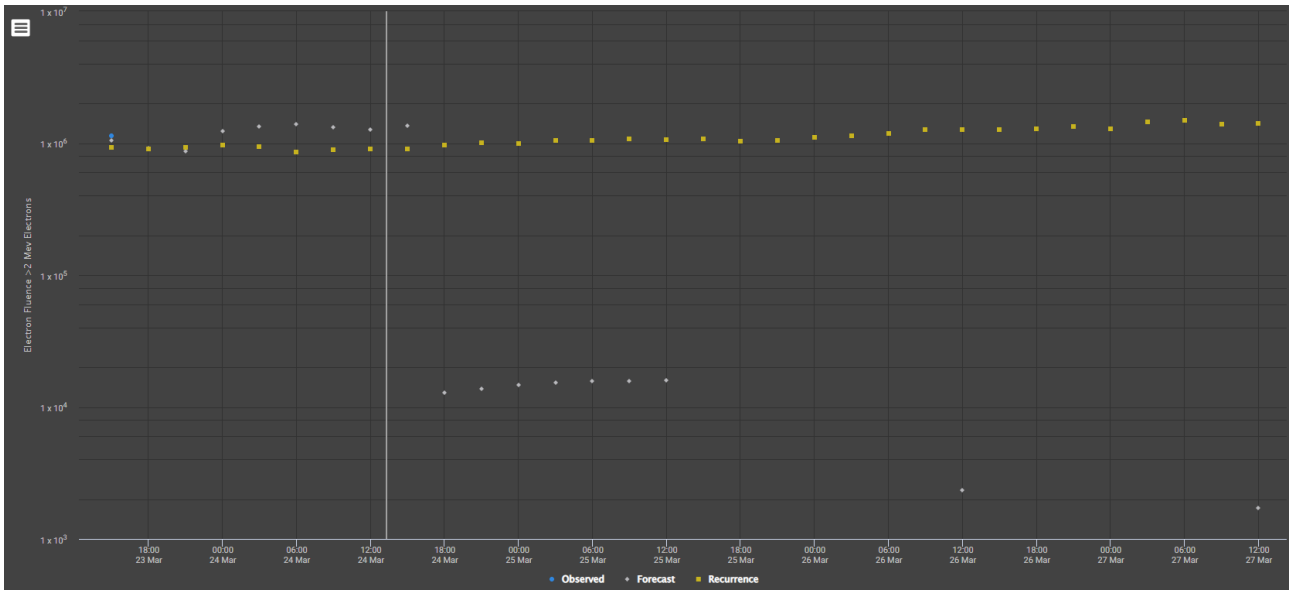
High Energy Electrons Event (≥ 2MeV):
GOES16 high energy electron flux is expected to remain at background levels initially giving ongoing geomagnetic response associated with the current connection to the HSS of CH12/- and expected CME impacts late day 1 or early day 2 (24-25 Mar). Associated geomagnetic activity expected to generally ease into days 3 and 4 (26-27 Mar), with the electron flux at GEO thought likely to see some rise to Moderate or High levels diurnally by the end of the period.

The associated 24-hour fluence expected to remain well below the Active threshold initially, with MOSWOC REFM providing generally good guidance. Fluence is likely to rise a little into the new UTC week, with an increasing chance of reaching Active fluence by the end of the period where MOSWOC REFM is not expected to provide as good guidance given the lack of CME influence and weaker HSS geomagnetic response in the last rotation.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	20	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: Latest MOSWOC REFM model output.



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